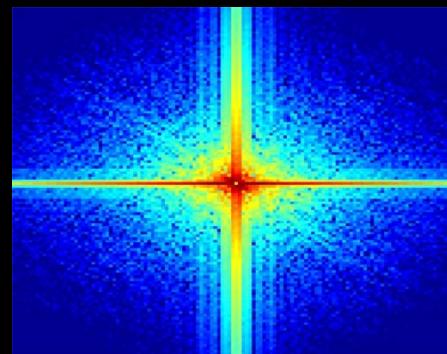


Spectral Processing of Point-sampled Geometry



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Markus Gross

ETH Zürich

Outline

- Introduction
- Spectral processing pipeline
- Results
- Conclusions

Introduction

Model Acquisition

- Range scans
- Depth images
- ...

Point-based
Geometry
Processing

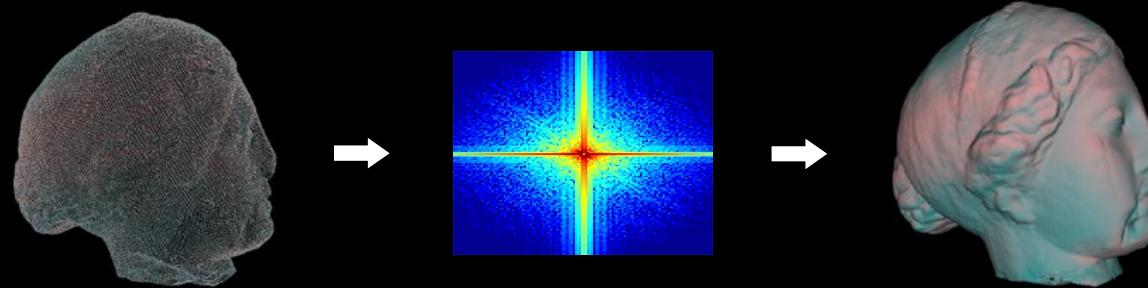
Point Rendering

- QSplat
- Surfels
- ...

Spectral
Methods

Spectral Transform

- Extend Fourier transform to 2-manifold surfaces



- ⇒ Spectral representation of point-based objects
- ⇒ Powerful methods for digital geometry processing

Applications

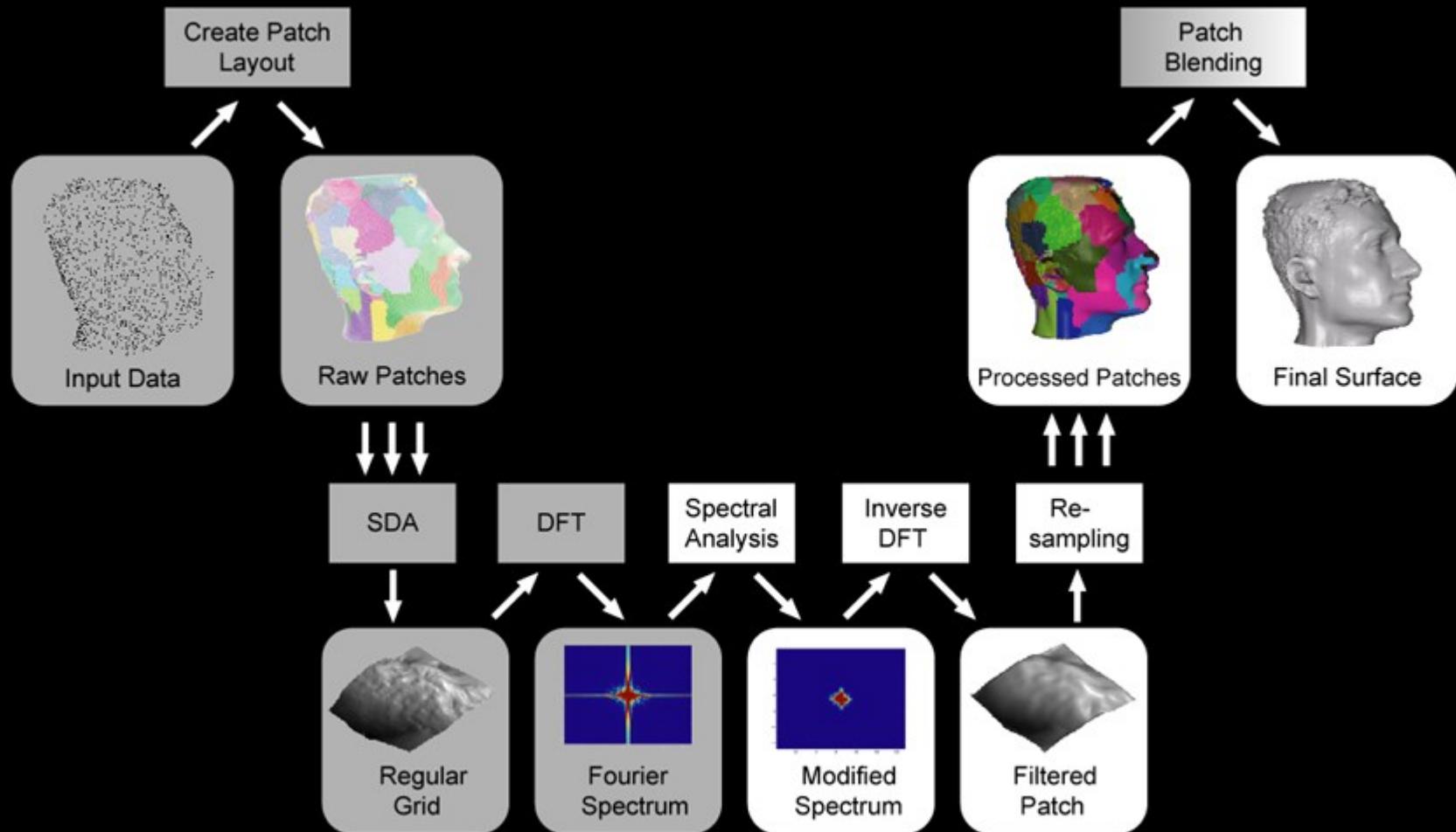
- Spectral filtering:
 - Noise removal
 - Microstructure analysis
 - Enhancement
- Adaptive resampling:
 - Complexity reduction
 - Continuous LOD

Fourier Transform

$$X_n = \sum_{k=1}^N x_k e^{-j2\pi \frac{nk}{N}}$$

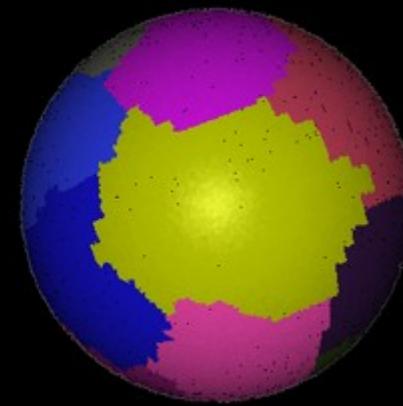
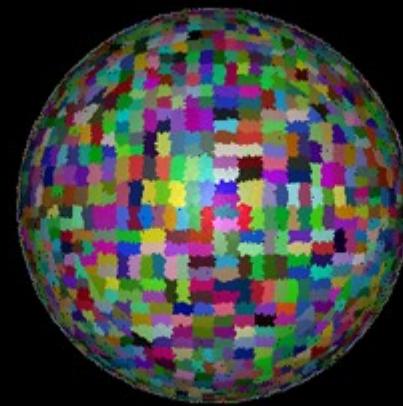
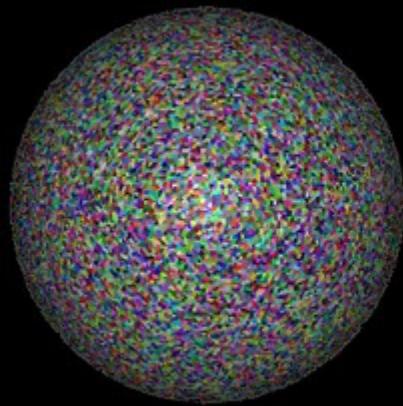
- Benefits:
 - Sound concept of frequency
 - Extensive theory
 - Fast algorithms
- Limitations:
 - Euclidean domain, global parameterization
 - Regular sampling
 - Lack of local control

Overview



Patch Layout Generation

Clustering \Rightarrow Optimization



Samples



Clusters



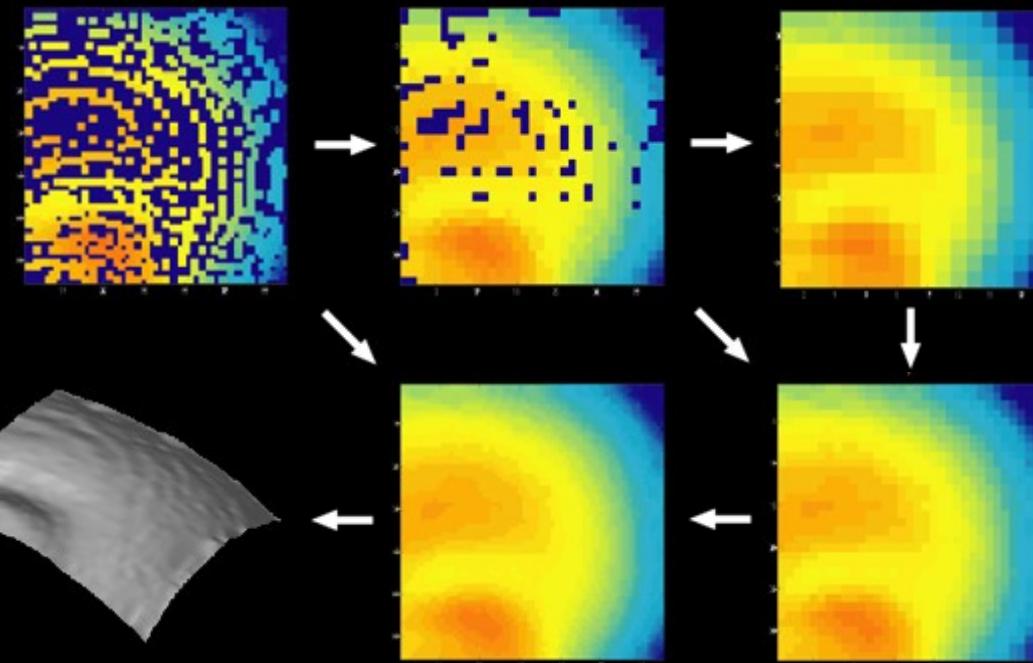
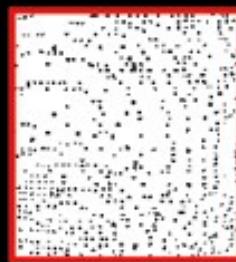
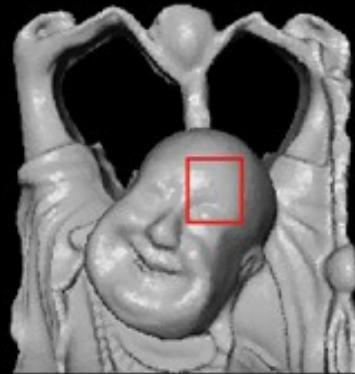
Patches

Patch Merging Optimization

- Iterative, local optimization method
- Quality metric:
 - ⇒ patch Size
 - ⇒ curvature
 - ⇒ patch boundary
 - ⇒ spring energy regularization

Scattered Data Approximation

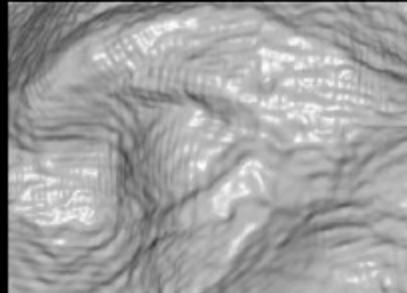
Hierarchical Push-Pull Filter:



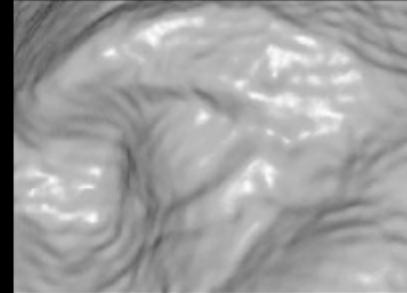
Spectral Analysis

- 2D Discrete Fourier Transform (DFT)
 - ⇒ Direct manipulation of spectral coefficients
- Filtering as convolution:
 - ⇒ Convolution: $O(N^2)$ ⇒ Multiplication: $O(N)$
- Inverse Fourier Transform
 - ⇒ Filtered patch surface

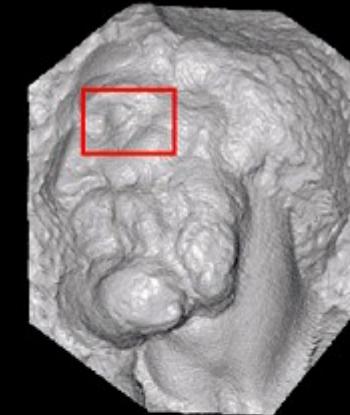
Spectral Analysis



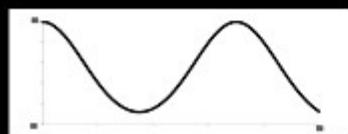
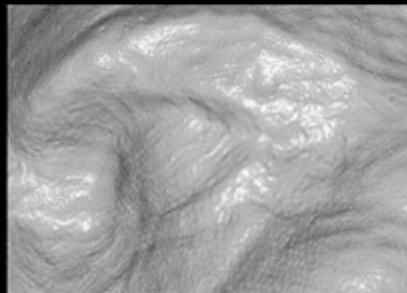
Ideal low-pass



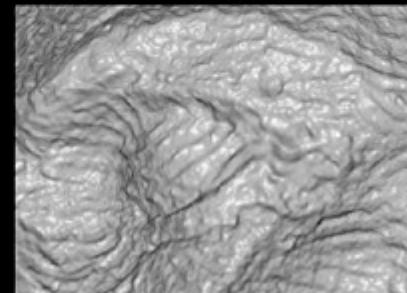
Gaussian low-pass



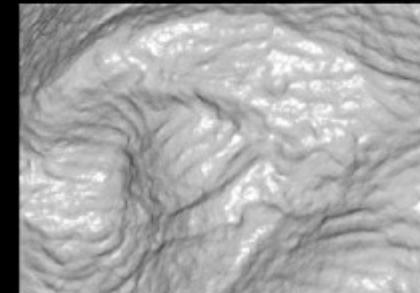
Original



Band-stop

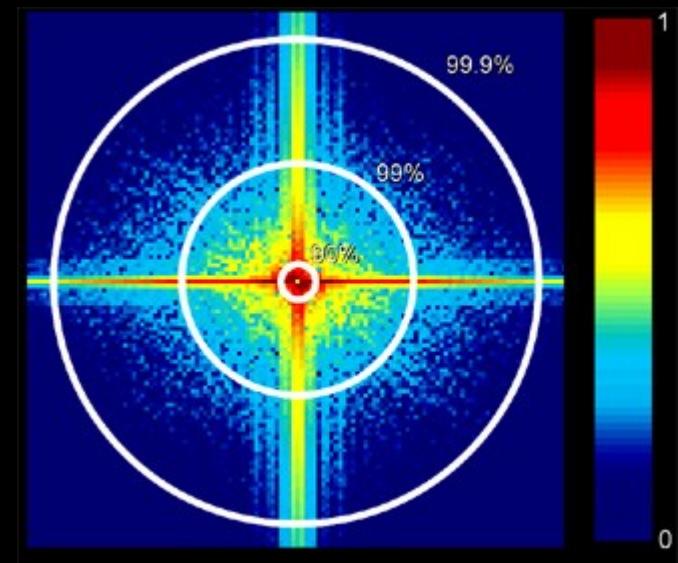


Enhancement



Resampling

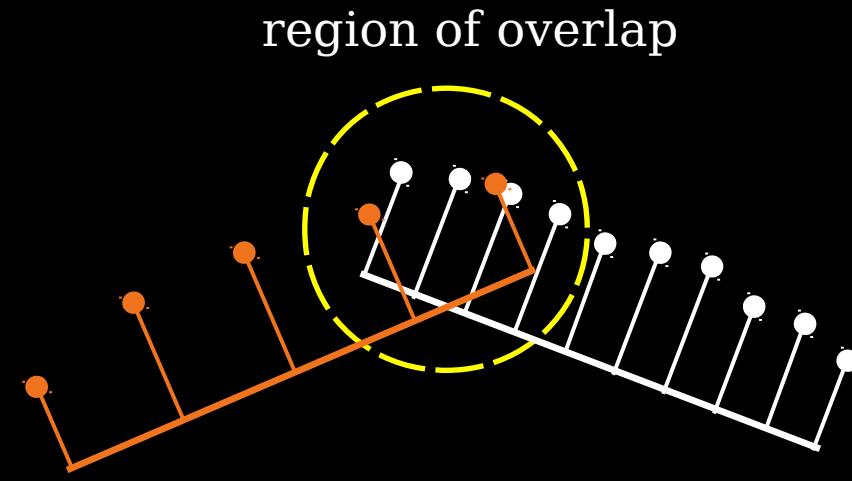
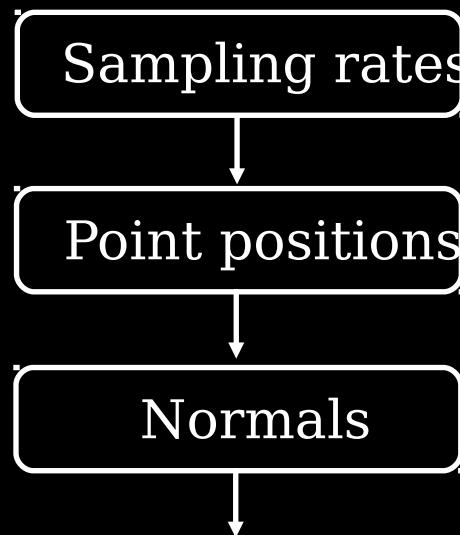
- Low-pass filtering
 - ⇒ Band-limitation
- Regular Resampling
 - ⇒ Optimal sampling rate (Sampling Theorem)
 - ⇒ Error control (Parseval's Theorem)



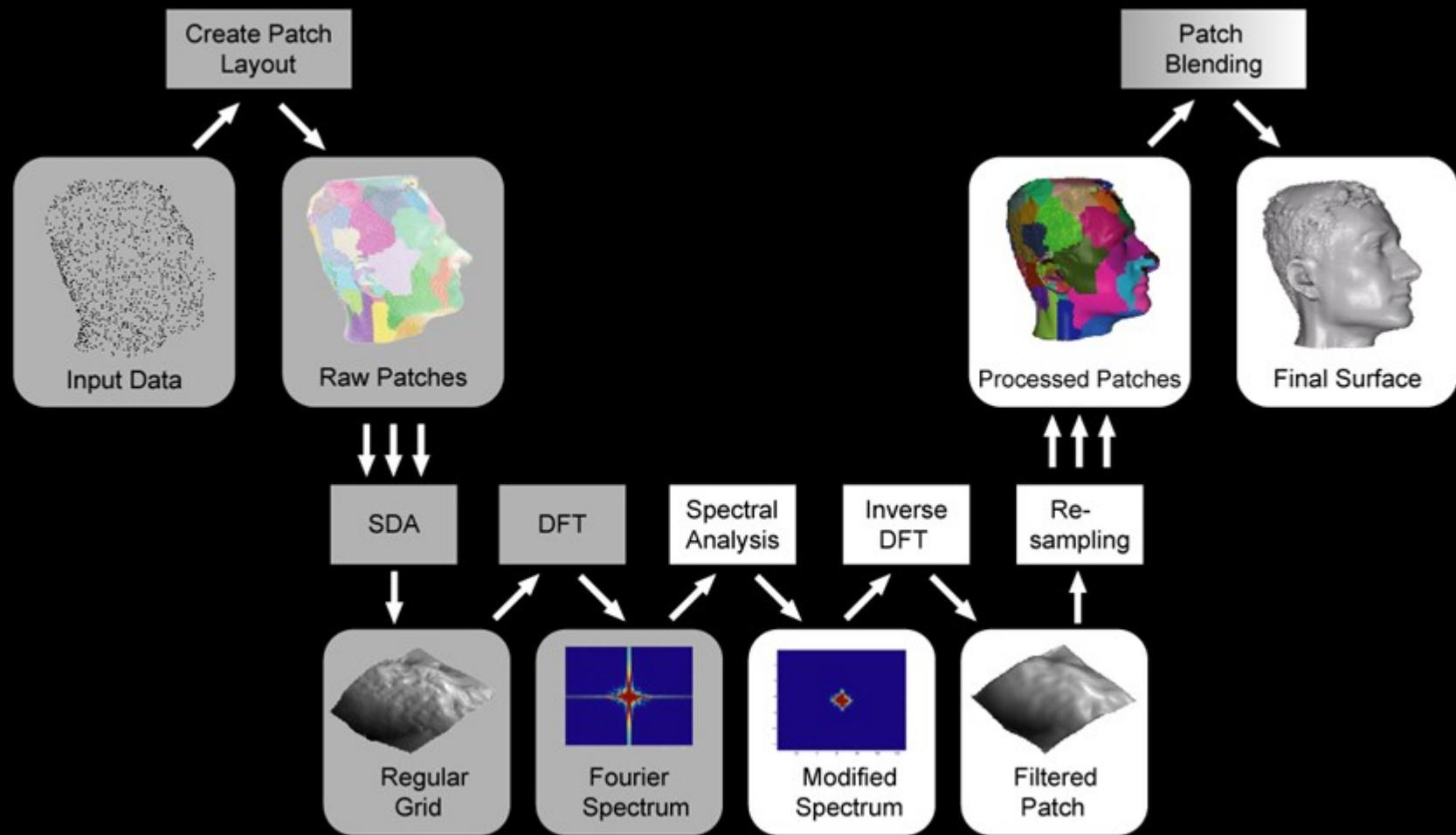
Power Spectrum

Reconstruction

- Filtering can lead to discontinuities at patch boundaries
 - ⇒ Create patch overlap, blend adjacent patches



Spectral Processing Pipeline



Surface Restoration



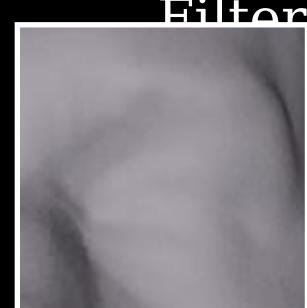
Original
Patch
noise+blur



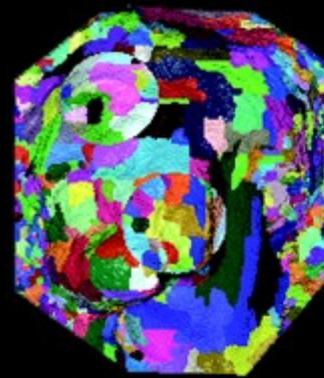
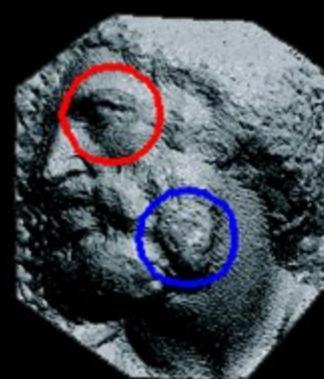
Gaussian



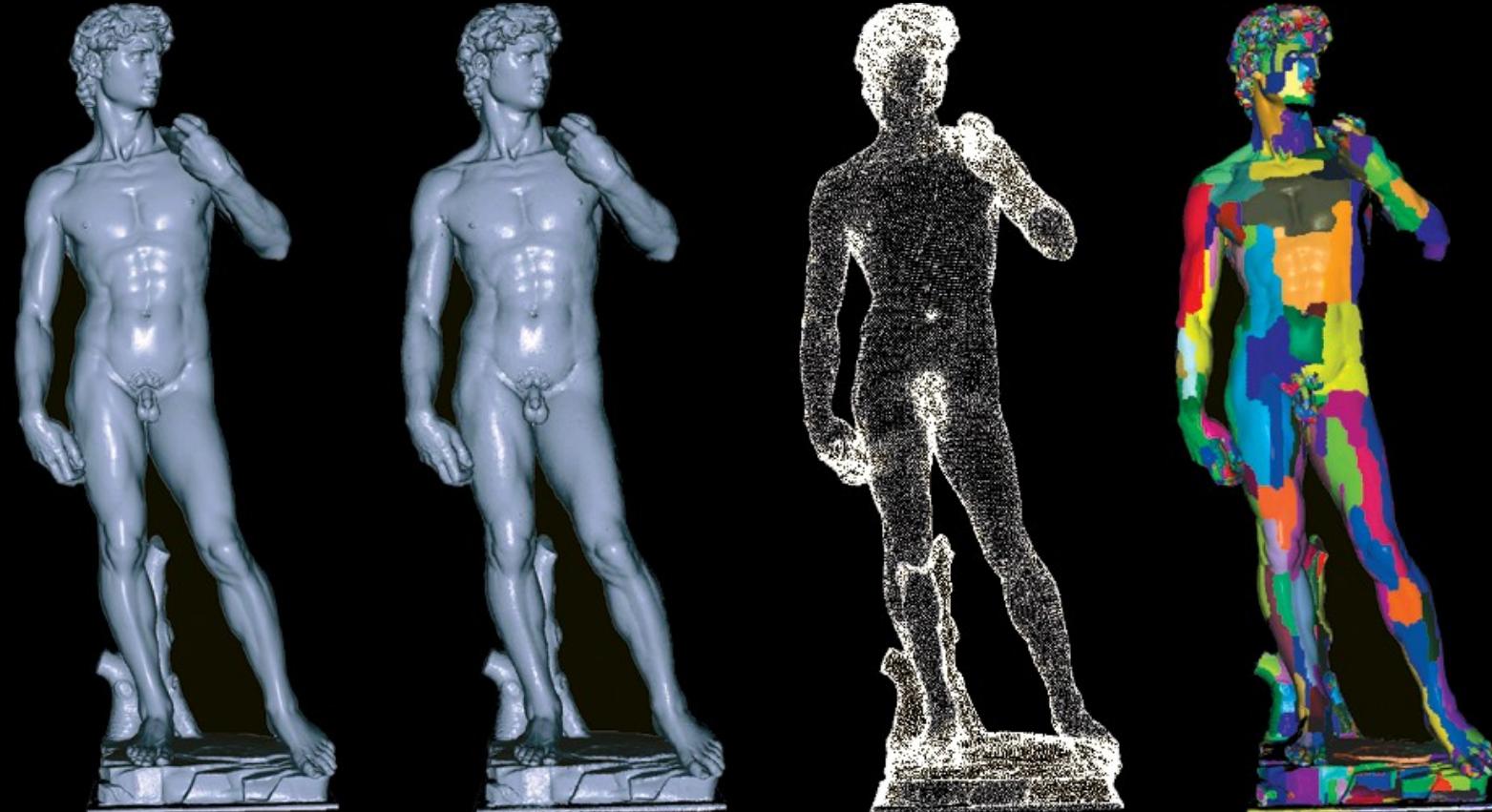
Wiener



Interactive Filtering



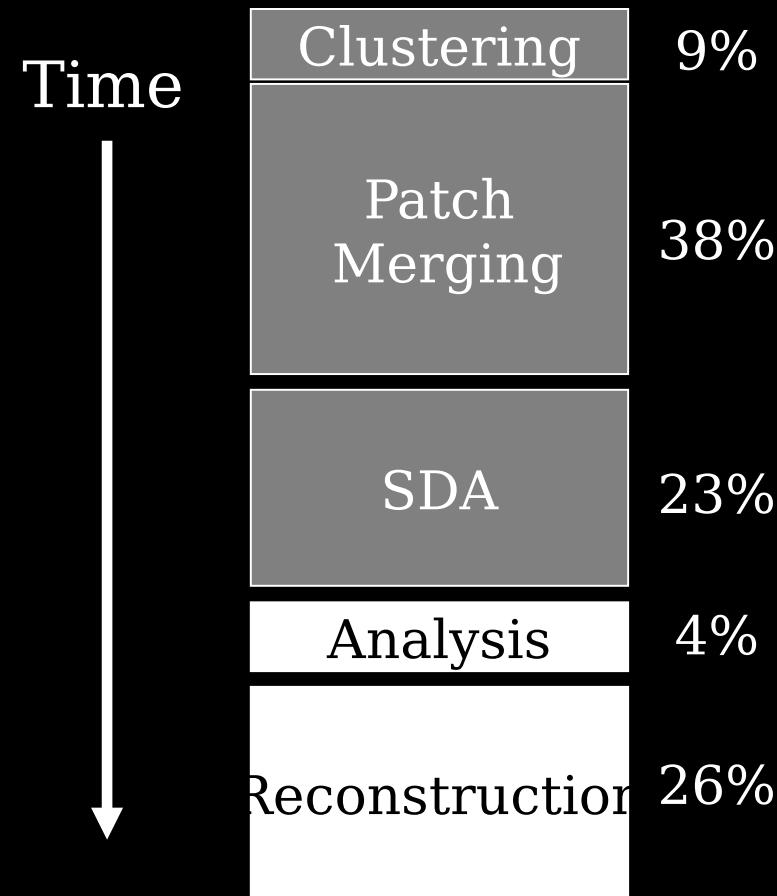
Adaptive Subsampling



4,128,614 pts.
= 100%

287,163 pts.
= 6.9%

Timings



Timings

			
#points	460,800	3,382,866	4,614
#patches	256	595	2,966
Preprocess	10.9	117.2	128.3
Total	15.8	153.0	189.6

Summary

- Versatile spectral decomposition of point-based models
- Effective filtering
- Adaptive resampling
- Efficient processing of large point-sampled models

Future Work

- Compression
 - ⇒ Scalar Representation + Spectral Compression
- Hierarchical Representation
 - ⇒ Modeling and Animation
- Feature Detection & Extraction
 - ⇒ Robust Computation of Laplacian

Acknowledgements

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